

Crustal Earthquakes of the Prince William Sound-Kodiak Region and Their Relationship to the Rupture Process of the 1964 Great Alaskan Earthquake

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Diane I. Doser
University of Texas at El Paso, Department of Geological
Sciences, El Paso, TX 79968-0555

Tel: 915-747-5851

Fax: 915-747-5073

Email: doser@geo.utep.edu

URL: http://www.geo.utep.edu/Faculty_Resumes/doser.html

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Investigations Undertaken

We are studying the source processes of crustal earthquakes in the Prince William Sound (Kayak Island to southern tip of Kenai Peninsula) and Kodiak Island (Kennedy Entrance to Chirikof Islands) occurring before and after the 1964 great Alaskan Earthquake. Little is known about the changes in the stress field and seismicity patterns before and after the 1964 mainshock, or the relation of crustal seismicity through time to the locations of the two major asperities that ruptured in the 1964 mainshock. Our efforts the first half of this year have concentrated on the Prince William Sound region. We have used body waveform modeling and earthquake relocations to examine the relation of seismicity to the subduction of the Pacific plate beneath Prince William Sound. The results of recent seismic refraction and reflection studies have provided important velocity constraints for our source modeling studies, as well as provided a detailed picture of the structure of the crust and megathrust zone. Other recent geophysical and geological studies (e.g. magnetics, gravity, strain rates, crustal deformation) are aiding us in our understanding of how crustal seismicity relates to the complex interaction of terranes along the plate boundary. We hope the information will help us to predict the long-term spatial and temporal patterns of seismicity along the plate margin and to determine the rate of seismic moment release within the region (information needed to evaluate how plate motion is being transferred inland from the plate margin).

Results

In the Prince William Sound region we have modeled the waveforms for all $m_b > 5.7$ earthquakes (18 events) occurring in the region between 1964 and 1983 (the start of routine moment tensor analysis of teleseismic digital seismic data for earthquakes of the region). We also collected arrival time information for all events of $m_b > 5.7$ in the region and relocated the seismicity occurring since the mainshock of

1964. Results of these studies were presented at the 1997 Fall Meeting of the American Geophysical Union (Veilleux et al., 1997) and the spring 1998 meeting of the Seismological Society of America (Velasquez et al., 1998). We have also submitted a paper on our studies to a special volume of Pure and Applied Geophysics on "The Mechanics of Shallow Subduction Zones". Our results suggest that pre-existing terrane boundaries may serve to concentrate stress within the subduction zone in this region, with many earthquakes located near changes in the structure of the upper or lower plate. Within Prince William Sound events are occurring above the plate interface along reverse faults or low angle thrusts. A second group of earthquakes occurs at 35 to 60 km depth on normal to normal-oblique faults. These events occur in a region where the subducting Pacific plate undergoes a rapid change in strike and dip.

Within Cook Inlet, to the west and well down-dip of the Prince William Sound asperity, earthquakes show a variety of mechanisms and many at depths of 50 to 70 km may be associated with complexities in the shape of the downgoing slab (complexities revealed by contouring the depth to the Benioff zone based on previously published cross sections). Most of the Cook Inlet events occurred after 1984, whereas few events of similar magnitude have occurred in the vicinity of Prince William Sound since 1984.

Over the summer we began work on the study of pre-mainshock seismicity in Prince William Sound. Twenty-seven events of $M > 6.0$ have been relocated and waveforms have been collected for 12 events. About half the waveforms have been digitized. Relocations show that many of the same regions that have been persistently active since 1964 were active prior to the mainshock. However, prior to the mainshock regions of the Kenai Peninsula and northern Cook Inlet showed significant activity that has not been seen in these region since 1964. Results will be presented at spring 1999 meeting of the Seismological Society of America.

Collection of waveform and arrival time information for post-mainshock earthquakes of the Kodiak Island region was completed in the summer of 1998. Digitization of waveform data has begun. A study of 7 events (post mainshock) in the Kennedy and Stevenson Entrance region (between the Kenai Peninsula and Kodiak Island) forms the basis of an M.S. thesis for Monique Velasquez (expected completion in December, 1999). She hopes to present preliminary results of her work at the spring 1999 meeting of the Seismological Society of America.

Analysis of waveform data for the remainder of the Kodiak Island region (17 events - post mainshock) is also underway. Arrival time information has been collected for 17 pre-mainshock earthquakes and these events will be located within the next two months. Requests for the seismograms of these earthquakes will be initiated within the next month.

In addition to our Prince William Sound/Kodiak Island research, we have completed the a waveform modeling (14 events) and relocation (23 events) study for southeastern Alaskan earthquakes. Results to date suggest the 1927 Sitka earthquake ($M_w = 7.0$) nucleated near the intersection of the Transition Zone and Fairweather faults, with rupture to the southeast along the Fairweather fault. Earthquakes of the 1973 Cross Sound sequence involved thrust faulting along the Transition Zone with rupture progressing to the WNW and up-dip during the sequence. In the St. Elias region, events from 1920 to 1965 exhibit a variety of focal

mechanisms (normal, strike-slip, thrust) at depths of 5 to 15 km, indicating deformation with the Yakutat Block above the Pacific plate. These mechanisms are similar to those seen in aftershocks of the 1979 St. Elias ($M_w=7.4$) earthquake. A study of earthquakes in the Fairweather region suggests that the 1944 ($M_w=6.0$) earthquake occurred along a reverse fault, while a $M\sim 6.0$ event in 1952 involved strike-slip faulting. Waveform modeling of the 1958 Fairweather earthquake indicates rupture nucleation at 16 km depth, with a bi-lateral rupture length of ~ 250 km. A comparison to recent seismicity suggests both moderate sized strike-slip and reverse events are common in the Fairweather region, with reverse faulting likely to occur in the restraining bends of the major strike-slip faults. Results of the research will be presented at the Fall 1998 Meeting of the American Geophysical Union (Doser and Lomas, 1998). A manuscript is in preparation for this study.

Non-Technical Summary

We are studying the faulting processes of over 36 large (magnitude > 5.5) earthquakes occurring in the southern Alaska region between 1920 and 1997. We are determining the earthquake locations, depths and causative faults. This information aids in understanding the deformation between the Pacific and North American plate over the past 70 years, and more importantly, the future earthquake hazards of the region. The study area focuses on the rupture zone of the 1964 Great Alaskan (magnitude 9.2) earthquake.

Data Availability

Digitized or paper copies of seismograms, first motion data and arrival time information are available from Dr. Diane Doser, doser@geo.utep.edu, (915)-747-5851.

Reports Published

Doser, D.I., and R. Lomas, Faulting processes of large southeastern Alaskan earthquakes (1920-1975), (abstract) submitted to Fall 1998 meeting, Amer. Geophys. Union., Sept., 1998.

Doser, D.I., A. Veilleux and M. Velasquez, Seismicity of the Prince William Sound Region for Over Thirty Years Following the 1964 Great Alaskan Earthquake, submitted to Pure and Appl. Geophy. special issue on "Shallow Subduction Zone Processes", April, 1998.

Veilleux, A. M., D. I. Doser and M. Velasquez, Source processes of earthquakes in the Prince William Sound region (1964-present) and their relation to the 1964 great Alaskan earthquake, (abstract) EOS Trans., American Geophysical Union, F480.

Velasquez, M., D.I. Doser and A. M. Veilleux, The relationship of seismicity in the Prince William Sound region (1964-1996) to the asperities of the 1964 great Alaskan earthquake, (abstract) Seismol. Res. Lett. 69, 172, 1998.